Oct. 22, 1963 H. A. KRAFTSON 3,107,535

GAS SAMPLING PROBE

Filed March 1, 1960 2 Sheets-Sheet 1

Fig. 1

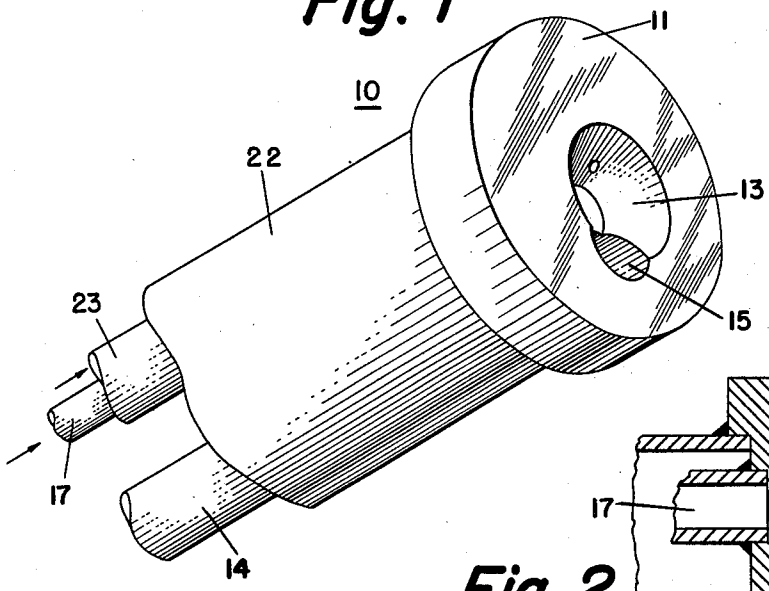


Fig. 2

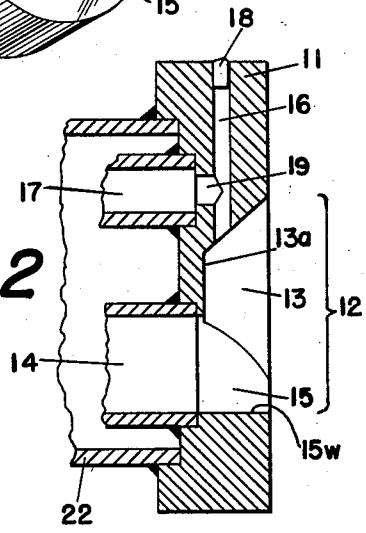
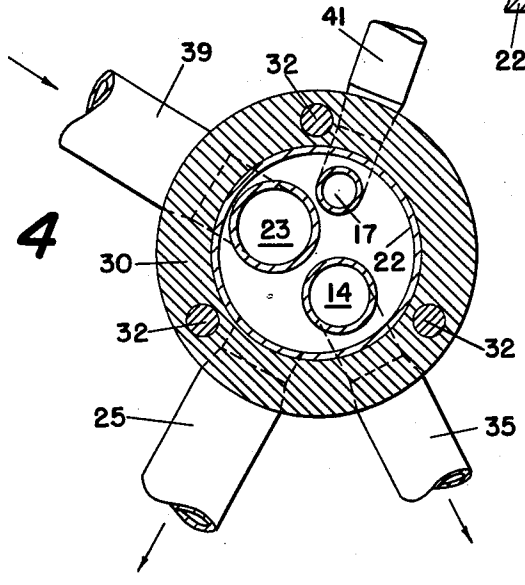


Fig. 4

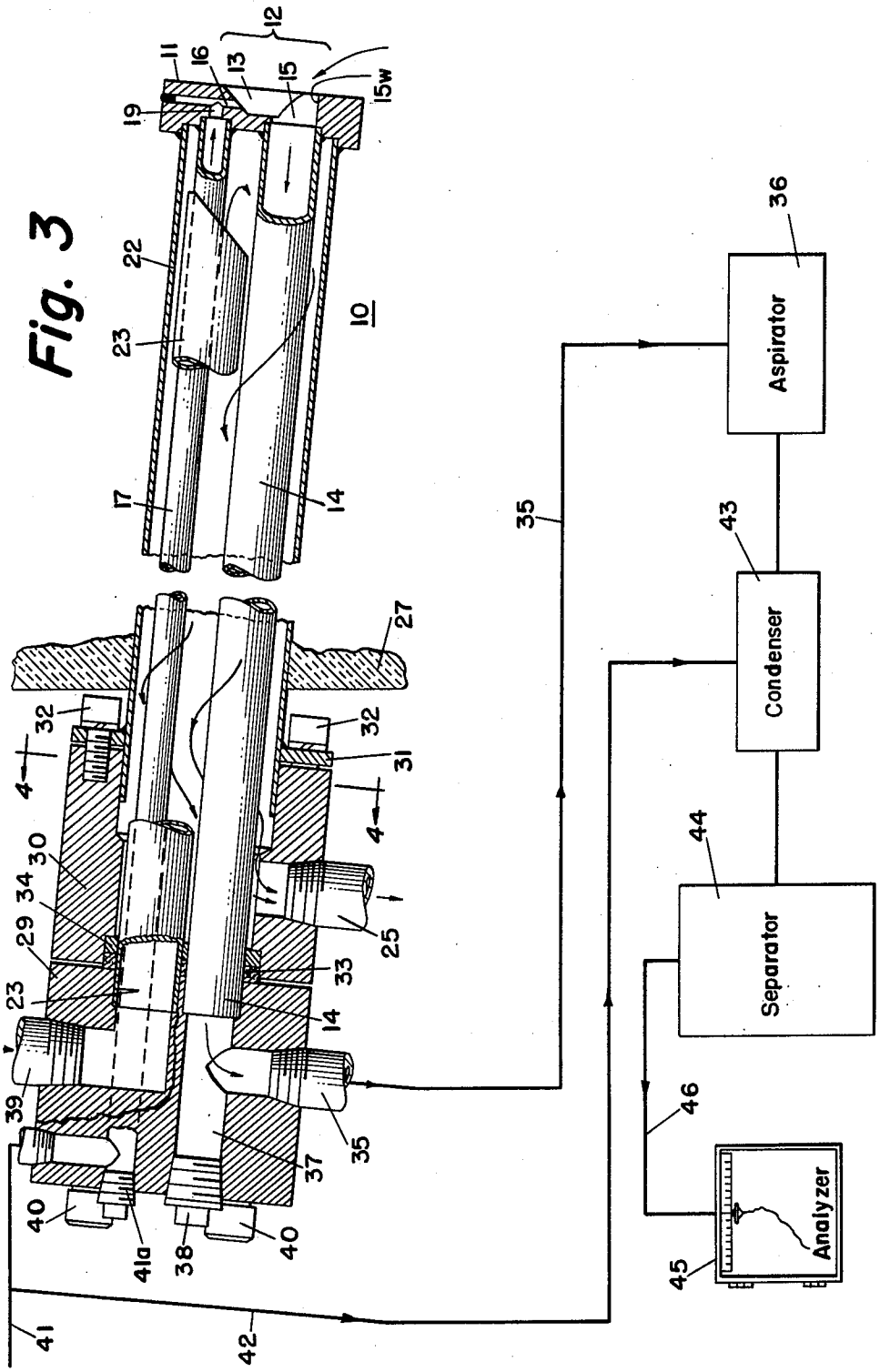


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Fig. 3



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3,107,535
GAS SAMPLING PROBE

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This invention relates to the sampling of gas from a dust-ladened atmosphere, and has for an object the provision of a gas sampling probe having improved means of washing the probe in the vicinity of the gas passageway in avoidance of accumulation of dust deposits.

In my Patent No. 2,987,921, I have discussed at some length the importance to the operation of furnaces of continued analyses of the flue gases in order that there may be achieved, either manually or automatically, improved operation of such furnaces. In my aforesaid patent I have disclosed improvements in structure providing water-washed probes which minimizes the introduction of water into the furnace or duct, and prevents accumulation of deposits in and about the inlet to the gas passageway through which a sample stream of the furnace atmosphere is removed. The present invention extends the field of successful continuous gas sampling to applications where the gas being sampled is at very high temperatures and contains high concentrations of solid and molten materials.

In open hearth furnaces, cement kilns and in cyclone furnaces burning powdered coal, the temperatures are not only high, in the range of from 2000° F. to 3200° F., but the dust concentration is quite great. At temperatures above the melting or oxidizing point of the nozzle metal an uncooled nozzle can quickly burn or oxidize away. Since the main source of cooling of the nozzle is the wash water flowing through it, any interruption to this water supply can result in almost immediate failure of the nozzle. Replacement of nozzles is inconvenient and causes interruption of service of the gas analyzing system. An advantage of this new design is that the wash water orifice is always cooled by the probe cooling water supply. Failure of the wash water supply does not require nozzle or orifice replacement.

In accordance with the present invention, there is provided a gas sampling probe having a fluid-directing passage with an orifice enclosed in an assembly which, by reason of the presence of cooling water flowing in heat transfer relation therewith, will maintain the exposed end of the probe at safe operating temperatures in the event of loss of wash water or of closure of the orifice. Further in accordance with the invention, there is provided a jet of water directed toward a surface to produce a continuous spray approximately half of which is aided in its flow into the sampling inlet by the aspirating means employed exterior to the probe or by the static pressure of the gas being sampled. Some of the water splashes onto a conical depression in the outer or front face of the probe preventing the deposition of molten or solid particles striking the face of the probe as a result of the flow of the sample gas stream entering the probe. A large percentage of the face of the probe is kept wet by the splashing of the water jet. Additionally a quantity of water is forcibly sprayed into the space surrounding the end of the probe. This functions to prevent the building up of any

deposit on the end of the probe by washing off any accumulation as it occurs or by preventing the adhesion of new particles.

In a preferred form of the invention the probe is provided with a relatively thick end cap having in its front face a frusto-conical wide-mouth opening or recess of substantial depth which is over half the thickness of the end cap. Communicating with the frusto-conical recess is a gas passageway. This passageway intersects with the frusto-conical recess near the periphery and provides a wall structure of limited extent disposed in a direction normal to a selected radius of the frusto-conical recess. Extending into the intermediate portion of the aforesaid recess is a flow passage for wash water which is directed diametrically across the frusto-conical recess and against the opposed surface thereby to produce a spray or splashing of wash water which is effective not only to keep the walls of the recess and the face of the probe wet at all times, but also to provide a source of wash water some of which flows with the withdrawn sample of furnace gases into the gas pasageway and some forcibly directed outwardly from the face of the probe.

Surrounding the gas passage and a water supply pipe is a housing and within that housing there is provided a source of cooling water directed generally against the inside face of the end structure to provide cooling thereof against the high temperatures encountered in the operation of high temperature furnaces.

In summary, there is provided a wide-mouth opening in the form of a frustum of a cone or similar shape and which along one side of the opening has merging therewith a gas passageway together with means for providing a spray or splash of water to keep the entrance to the gas passageway clear.

For a more detailed understanding of the invention, reference is to be had to the following description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is an isometric view of the forward portion of the probe;

FIG. 2 is a sectional view of the end structure and including portions of the pipes connected thereto;

FIG. 3 is a sectional view of the probe as a whole and, including diagrammatically, associated apparatus for the analysis of the furnace gases; and

FIG. 4 is a sectional view taken on the line 4—4 of FIG. 3.

Referring now to FIGS. 1 and 2, the invention has been illustrated in one form as comprising probe **10** having a relatively thick forward end structure **11**. To provide a relatively wide-mouth opening **12** for a gas passageway communicating with a pipe **14**, the end structure **11** is provided with a relatively deep frusto-conical recess **13**. The larger diameter of the recess preferably coincides with the front face of the end structure **11** while the smaller diameter **13***a* of the frusto-conical recess lies inwardly of the middle portion of the structure **11**. The sampling line or pipe **14** is welded to the end structure **11**. The structure **11** has an opening in communication with the pipe **14** and the frusto-conical recess **13**.

As shown in FIGS. 1 and 2, the end structure **11** includes a hole **15** defined in large part by wall surface **15***w*, to provide a gas passageway communicating with the pipe **14**, this passageway **15** intersecting the frusto-

conical recess 13 in a region adjacent the periphery of the base 13*a* of recess 13. Thus the wide-mouth opening 12 includes the conical wall of recess 13 and the cylindrical wall of the passageway 15 communicating with the pipe 14.

By reason of the structural features thus far described, there is provided a configuration which has proven in practice to be highly effective in remaining open for unobstructed flow of gas into the sampling pipe 14. The described configuration has proven highly effective in cleaning actions produced by a stream of wash water. These cleansing actions will now be described.

Extending radially of the conical recess 13 is a small fluid-directing passage 16 having an opening or orifice on the wall of the conical recess 13. The passage 16 is supplied with wash water from a wash water supply pipe 17 which has its end portion welded to the end structure 11. The passage 16 may be formed by drilling the end structure 11 in a direction radially of the frustum of the cone and radially of passageway 15. The outer end of passage 16 is closed by a plug 18. Water, supplied under pressure by way of supply pipe 17, flows through an opening 19 into the passage 16, and by that passage is directed diametrically across the frusto-conical recess 13 and diametrically across the cylindrical entrance passageway 15.

The wash water in the form of a jet or stream is directed against the opposing wall 15*w* which, it will be noted in FIG. 2, is in cross section normal to the radially disposed passage 16. The jet of wash water in striking the cylindrically curved opposing surface of wall 15*w* forming the entrance 15 produces a spray or splash of the wash water, that is to say, the directed stream of wash water in striking the opposite wall portion comprising the cylindrically curved surface of wall 15*w* is broken up into a plurality of small droplets which provide washing and cleansing actions in a plurality of directions. More particularly, the spatter in part is effective to wet and to maintain wet the walls of the wide-mouth opening 12 and to drive from the surface dust particles which tend to adhere or to coalesce thereon. The spatter is effective to provide a spray of water extending across the entrance of the sampling line 14 and outwardly from the face of the end structure 11. The spatter or splashing streams of wash water within the region of the cylindrical passageway 15 is aspirated into the sampling line or pipe 14 and flows with the gas sample to the analyzing apparatus which will later be described.

Surrounding the pipes 14 and 17 is a larger pipe or cylindrical housing 22, one end of which is welded to the end structure 11 in a manner similar to the welding of pipes 14 and 17, the welding beads in each case having been illustrated in FIG. 2.

As shown in FIG. 1, there is additionally disposed within the housing 22 a supply pipe 23 for the flow of cooling water into the assembly. As best shown in FIG. 3, the open end of the pipe 23 terminates in a region adjacent the inside face of the end structure 11 in order that the cooling water flowing through the pipe 23 will intimately contact the inside face of the end structure 11 and the associated tubing to provide maximum cooling thereof. The cooling water after its exit from the supply pipe 23 flows round and about the pipes 14 and 17 and exits from the assembly by way of the pipe 25. The flow of cooling water may be in the reverse direction for certain uses.

In FIG. 3 the probe 10 has been illustrated in its preferred position for the sampling of gases from a furnace, kiln or other compartment, a fractional part 27 of the wall of a furnace being illustrated. It will be noted that the outer cylindrical housing 22 extends through an opening in wall 27 and in a downwardly inclined direction. It is preferred that the probe 10 be inclined downwardly so that any spatter from the stream of wash water from the fluid-directing passage 16 which may be outwardly directed will drain from the lower right-hand end of the probe. If the probe were tilted upwardly, any wash water which might tend to flow downwardly over the face of the end structure 11 would then also flow rearwardly of the probe or toward the wall 27. Such a flow could cause problems in the disposal of the water running down the outside of the probe.

The probe assembly 10 includes a pair of connector blocks 29 and 30. The outer cylindrical housing 22 terminates within one end portion of the block 30 and it is secured thereto by a plurality of cap screws 32 which extend through a fastening flange 31 secured, as by welding, to the housing 22. The end block 29 is provided with passages to receive the ends of pipes 14, 17 and 23. A lateral opening is provided in the block 29 into which there is threaded a pipe 35 forming a part of the sampling line or pipe 14 which extends to an aspirator 36 for the application of suction to the pipe 14. It will be noted that the pipe 14 terminates at a longitudinal passage 37 in block 29 and to which the pipe 35 is in communication through the lateral opening. The passage 37 is closed at one end by a plug 38 which may be removed for cleaning passage 37 and pipe 14. The pipe 23 for the cooling water terminates at an internal passage of the block 29, which passage communicates with a cooling water supply pipe 39.

The pipes 14 and 23 and the wash water supply pipe 17 extend through openings in a retainer 34 and a gasket 33. A fluid-tight seal is provided by the gasket 33 around pipes 14, 17 and 23. The sealing pressure upon the gasket 33 is developed by the clamping pressure exerted by the two blocks 29 and 30. Thus the two blocks 29 and 30 are pulled against retainer 34 and gasket 33 by a series of cap screws 40 which extend through block 29 and threadedly engage openings in block 30.

It is to be observed that the wash water supply pipe 17 terminating within the block 29 is in communication with supply pipe 41 through a lateral opening, a cleaning plug 41*a* being provided axially of pipe 17. A branch line 42 diverts some of the water from line 41 to a condenser 43. The supply line 41 may also be used to supply the cooling water to the pipe 39. In addition, the orifice 16 may be supplied with water from the housing 22, in which case the pipe 17 would be omitted with opening 19 in direct communication with the interior of housing 22. To assure adequate pressure for the jet of water to issue from orifice 16, a back pressure should be developed at the outlet pipe 25 as by provision of a throttling valve, back-pressure regulator, or other flow restriction.

The probe thus far described lends itself to operation in systems of the kind disclosed in U.S. Patent 2,895,335, dated July 21, 1959. More particularly, the aspirator 36 is supplied with steam or water for the development of suction applied by way of line 35 to the sampling pipe 14 for withdrawal into that sampling line of a stream of furnace gases. This stream will have mixed therewith some of the wash water resulting from the spatter in the region of the cylindrical surface 15*w*. After the cooling of the gas sample as within a condenser 43, the gas sample is directed into a separator 44. Within the separator 44 water particles, condensed steam and entrained solid particles are separated from the sample stream. A solid-free gas sample flows from separator 44 by way of line 46 to the analyzer 45. The analyzer 45 may be of conventional design and suited to the measurement of the selected constituent of the furnace atmosphere as for example, for the measurement of the oxygen content or for the measurement of carbon dioxide.

Now that a preferred embodiment of the invention has been described, it will be understood that modifications thereof may be made within the scope of the appended claims.

More particularly, the wall 15*w* need not be cylindrical nor need the cylindrical passageway be disposed at right angles to a diameter of the end structure 11. It will

be obvious to those skilled in the art that various geometrical shapes may be utilized to provide the wide-mouth opening which has an increasing cross-sectional area from the smaller base to the front entranceway and with which there is merged the entrance to the sampling line provided by pipe **14**. With other geometrical arrangements it will be understood that the fluid-directing passage **16** will direct the wash water at the proper angle to produce the spatter which has proved effective in maintaining the gas passageway free of gas-obstructing accumulations of dust particles. It will be understood that the pressure of the wash water supplied to passage **16** can vary over a substantial range.

In one application of the invention of orifice of the fluid-directing passage **16** had a diameter of 0.06". To that orifice there was supplied wash water under a pressure producing a flow rate of approximately 0.2 gallon per minute. The end structure **11** had a diameter of about 1½ inches and a thickness of 7/16 inch. The frusto-conical entranceway had a base of ¾ inch diameter, the cone extending into the end structure **11** one-quarter of an inch. The passageway **15** had a diameter of 13/32 inch and it was disposed on an axis which produces a slight overlap of that opening with the inwardly disposed base of the recess **13**. The wide-mouth opening **12** was disposed asymmetrically in relation to the end structure **11**, that is to say, the structure **11** was not concentric with either the cone **13** or the passageway **15**. Thus the axes of the cone **13**, the passageway **15** and the axis of the end structure **11** were all displaced one from the other. The foregoing features have been shown in the embodiment illustrated in the accompanying drawings.

Finally, it is to be observed that there are no protruding parts and that even if there should be a failure of flow of wash water there will be lacking any protruding nozzle structure to be burned away. In the event of failure of flow of wash water, the end structure **11** will continue to be cooled by the flow of cooling water by way of the supply pipe **23**. It is emphasized again that the jet or stream of water from the passage **16** produces by its impact with the wall **15***w* a continuous spray in the form of a spatter or splash. Approximately half of it is withdrawn into the sampling pipe **14** by the action of the aspirator **36**. The remainder of the wash water is effective in producing a continuous washing of the entrance surfaces to prevent the deposition of molten or solid particles and washes these particles out of the entrance to the sampling line **14**. Since the continuous jet of water is broken up into the spatter, the loss of a part of it into the furnace does no harm since, at the high temperatures for which the probe is designed, the spatter rapidly evaporates.

What is claimed is:

1. A probe for withdrawal of gases from a dust-ladened atmosphere comprising an end cap of substantial thickness, said end cap having a recess in the form of a frustum of a cone with the larger diameter of said recess at the surface of the end cap and the smaller diameter of said recess located inwardly of said surface, a gas passageway extending through said end cap and having a diameter less than said larger diameter and disposed for merging relationship with said cone on one side thereof relative to said smaller diameter, whereby there is formed a wide mouth opening to said gas passage, said wide mouth opening being characterized by one portion in the shape of said frustum of a cone and another portion by the cylindrical walls of said gas passageway, said end cap having radially thereof a fluid-directing passageway, said fluid-directing passage being in spaced relation to the cylindrical surface of said gas passageway and between said larger and smaller diameters of said frustum of said cone, and a connection to said fluid-directing passage for supply of wash water thereto under pressure for producing a stream of wash water directed radially across said frustum of a cone and against said cylindrical surface of said gas passageway, said cylindrical surface redirecting said stream of wash water to produce a widespread spray consisting of small droplets of liquid, whereby the exposed surfaces of said gas passageway are maintained wet and said spray is effective in preventing accumulation of dust particles in and about said wide-mouth opening and in and about said gas passageway.

2. The probe of claim 1 in which said end cap has connected thereto one end of a pipe of large diameter, said pipe having disposed therein a second pipe in communication with said gas passageway, a third pipe for carrying wash water to said fluid-directing passage, and a fourth pipe for directing cooling water against said end cap and around and about said other pipes to maintain cool said assembly including said end cap thereby to prevent oxidation and erosion thereof due to high-temperature gas to which said end cap may be exposed.

3. A probe for withdrawal of gases from a dust-ladened atmosphere comprising an entrance structure having a water-washed wide-mouth opening in the shape of a frustum of a cone the walls of which diverge to provide an increasing cross-sectional area for the opening which is greatest at the outermost entrance portion and less at a region inwardly spaced from the entrance portion, an unobstructed gas passageway opening into said region of less cross-sectional area with an entrance portion thereto formed by a cylindrical wall merging with the frusto-conical opening with the outer limit of the cylindrical wall displaced radially outwardly from the widest portion of the outer diameter of the frusto-conical wide-mouth opening, for receiving gases from said wide-mouth opening, said gas passageway having a cross-sectional area materially less than said wide-mouth opening at said outermost entrance portion whereby dust deposits must bridge said outermost entrance portion of said wide-mouth opening before there can be stoppage of gas flow into said gas passageway, and means external to the whole of said gas passageway comprising a small-bore water-directing passageway extending radially of said frusto-conical opening and radially of said entrance to said gas passageway for directing wash water diametrically across said wide-mouth opening and against said cylindrical wall in the region of said gas passageway for the production of spatter.

4. A probe for withdrawal of gases from a dust-ladened atmosphere comprising an entrance structure having a water-washed wide-mouth opening in the shape of the frustum of a cone the walls of which diverge to provide an increasing cross-sectional area for the opening which is greatest at the outermost entrance portion and less at a region inwardly spaced from the entrance portion, an unobstructed gas passageway radially displaced outwardly of the region of smaller cross-sectional area, said entrance structure having a cylindrical wall portion in alignment with said gas passageway and forming a continuation thereof merging with the walls of said entrance structure, said gas passageway having cross-sectional area materially less than that of said wide mouth at said outermost entrance portion whereby dust deposits must bridge said outermost entrance portion before there can be stoppage of gas flow into said gas passageway, and means for directing wash water diametrically across said wide-mouth opening and against said cylindrical wall portion for production of spatter of said wash water within and about the entrance portion of said gas passageway, a portion of the wash water being directed outwardly by said cylindrical wall portion and acting to prevent bridging of said wide-mouth opening by wetted dust particles.

5. A probe for withdrawal of gases from a dust-ladend atmosphere comprising an entrance structure having a water-washed wide-mouth opening at least in part in the shape of a frustum of a cone the diverging walls of which provide an increasing cross-sectional area which is greatest at the outermost entrance portion and less at a region inwardly spaced therefrom, means for directing wash

water from a first side of said wide-mouth opening across the same and against an opposite wall portion, and an unobstructed gas passageway of cross-sectional area materially less than that of said outermost entrance portion in direct communication with said entrance portion, a part of said opposite wall portion extending toward and merging with the wall of said passageway, and means for directing said wash water comprising a water-directing small-bore passageway extending through said entrance structure at an angle substantially normal to said opposite wall portion for producing water-spatter directed outwardly across said wide-mouth opening, around and about

said diverging walls, and inwardly and across said gas passageway for minimizing dust deposits.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,107,535 October 22, 1963

Harry A. Kraftson

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 7, line 7, for "and" read -- said --.

Signed and sealed this 4th day of August 1964.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents